

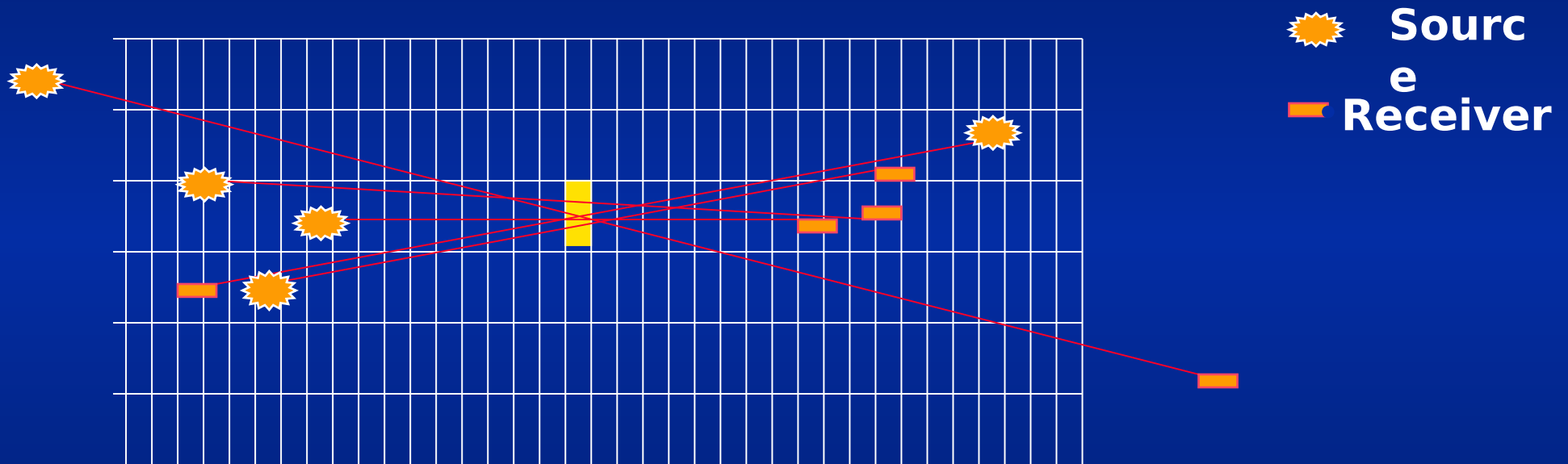
STACKING

At the end of this Session, you will be able to:

- Define the term 'Normal Moveout' as used in data processing.
- Define the term 'NMO correction'.
- Define the term 'NMO corrected CMP gather' as used in velocity analysis.
- Define the term 'stacking velocity'
- Define the term 'CMP stacking' as used in processing
- Define the term 'fold' as used during stacking
- Describe the relationship between fold of stack and the change in signal to random noise ratio during stacking
- Describe the relationship between fold of stack and the amplitude of the stacked trace

What is Stacking?

- We take all the traces that have the same common mid point (in 2D or the same bin (3D) & sum them together.

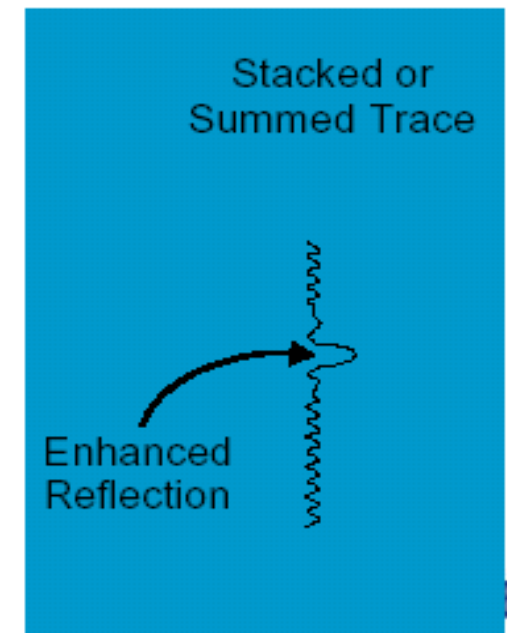
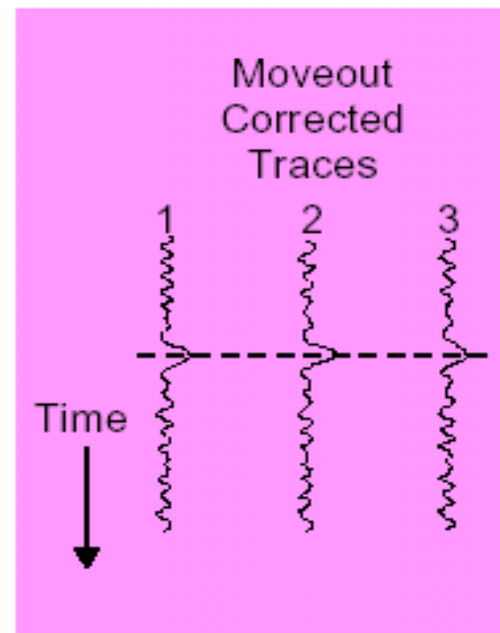
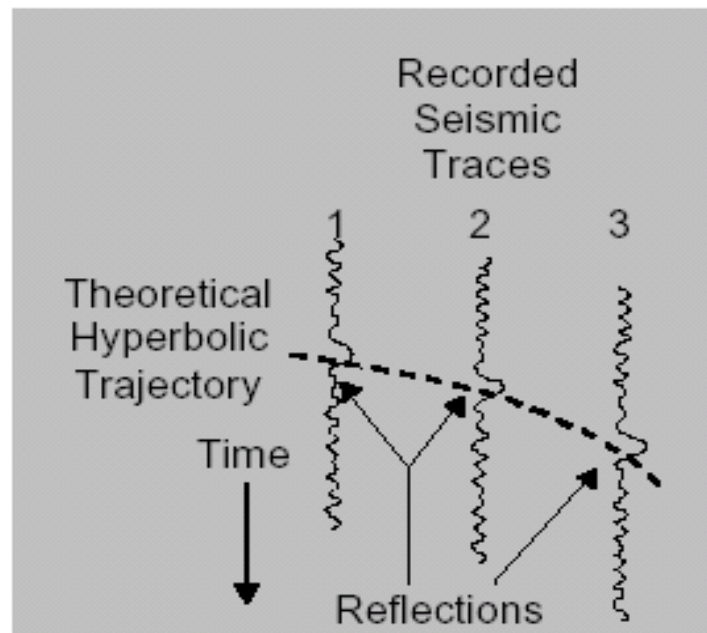
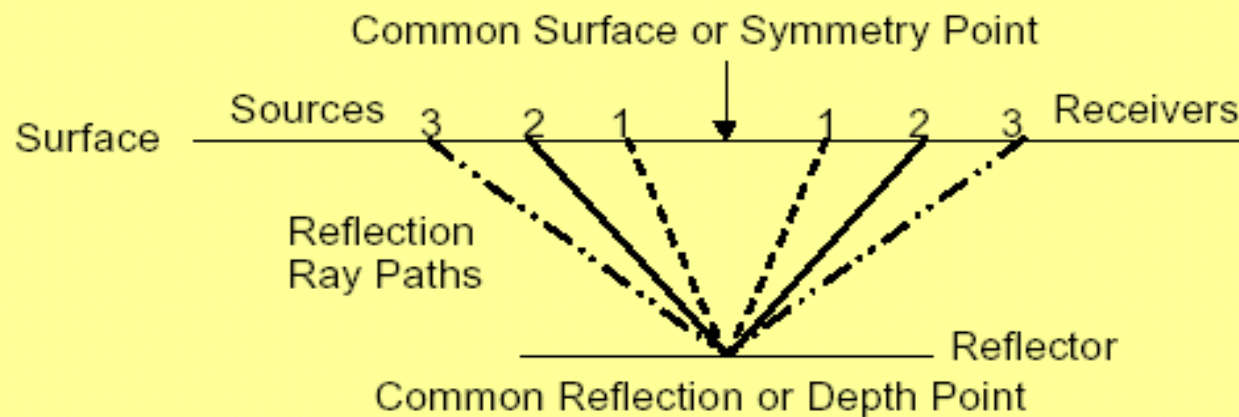


- The CMP locations for the 5 source / receiver pairs all fall in the same bin.
- These 5 traces would be collected together 'gathered' and then summed together to make 1 trace 'stacked'

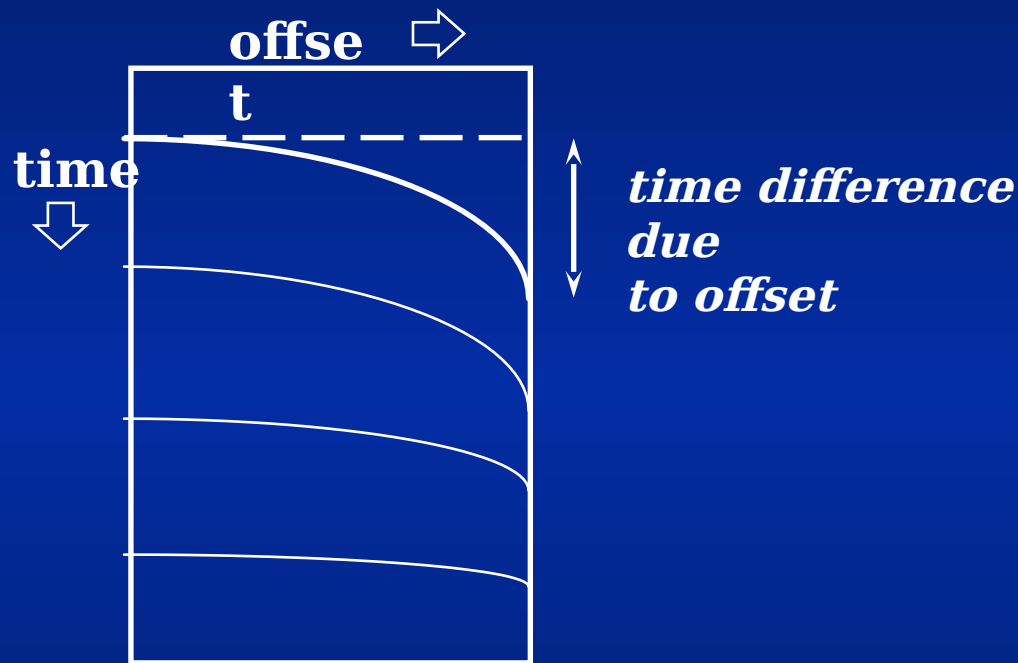
NMO and CMP Stack

- **SORT the data to the CMP domain**
- **Apply Normal Moveout correction (NMO) to align our primary events in the CMP domain**
- **Sum (STACK) the traces within the NMO corrected CMP gathers**

CDP Imaging Method



'Flattening' our Primary Events



CMP gather

Must correct for time differences due to offset within the CMP by applying

NMO correction

Normal Moveout - NMO

The variation of reflection arrival time because of variation in the shotpoint to geophone distance (offset)

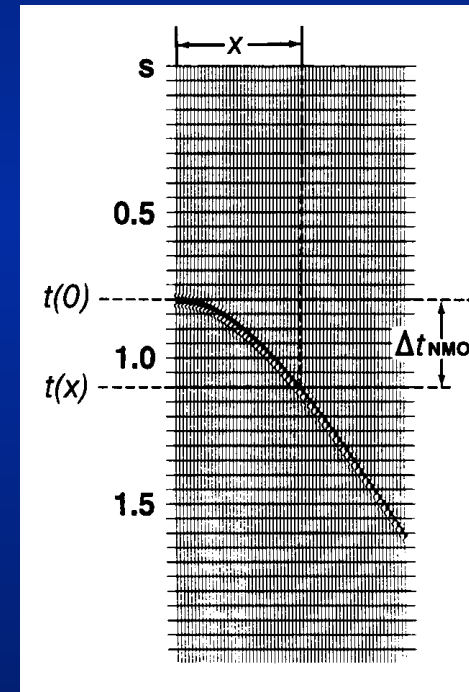
This variation in arrival time is hyperbolic on a CMP gather

$$t_x^2 = t_0^2 + X^2 / V^2$$

In the presence of dip, the NMO equation is modified as follows

$$t_x^2 = t_0^2 + X^2 \cos^2 \theta / V^2$$

- t_x travel time at offset x
- t_0 travel time at zero offset
- X offset
- V NMO velocity
- θ angle of reflector to horizontal



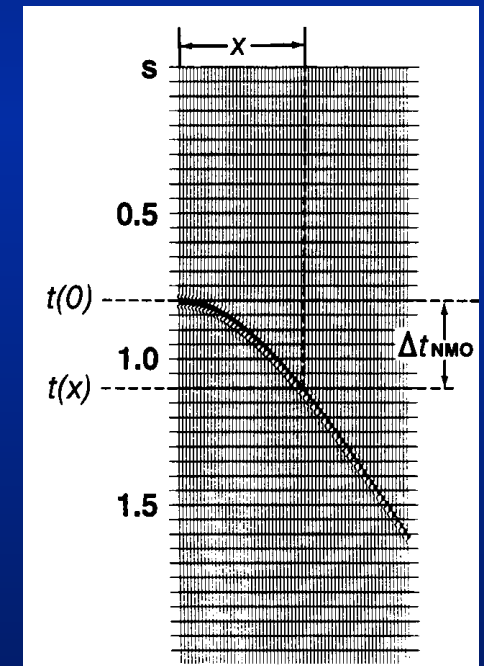
Normal Moveout correction

The moveout correction Δt is the time correction applied to each offset

$$\Delta t = t_x - t_0$$

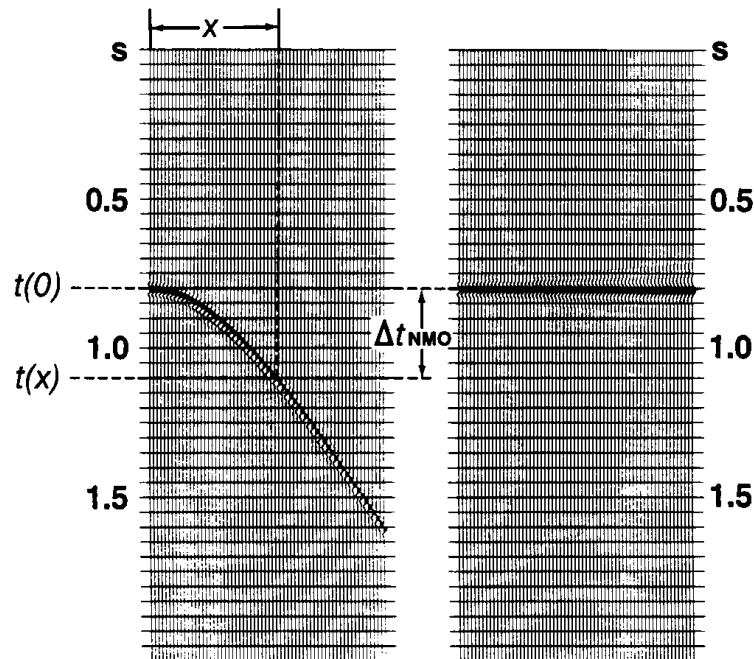
$$\Delta t = \sqrt{t_0^2 + \frac{x^2}{v^2}} - t_0$$

t_x travel time at offset x
 t_0 travel time at zero offset
 x offset
 v velocity



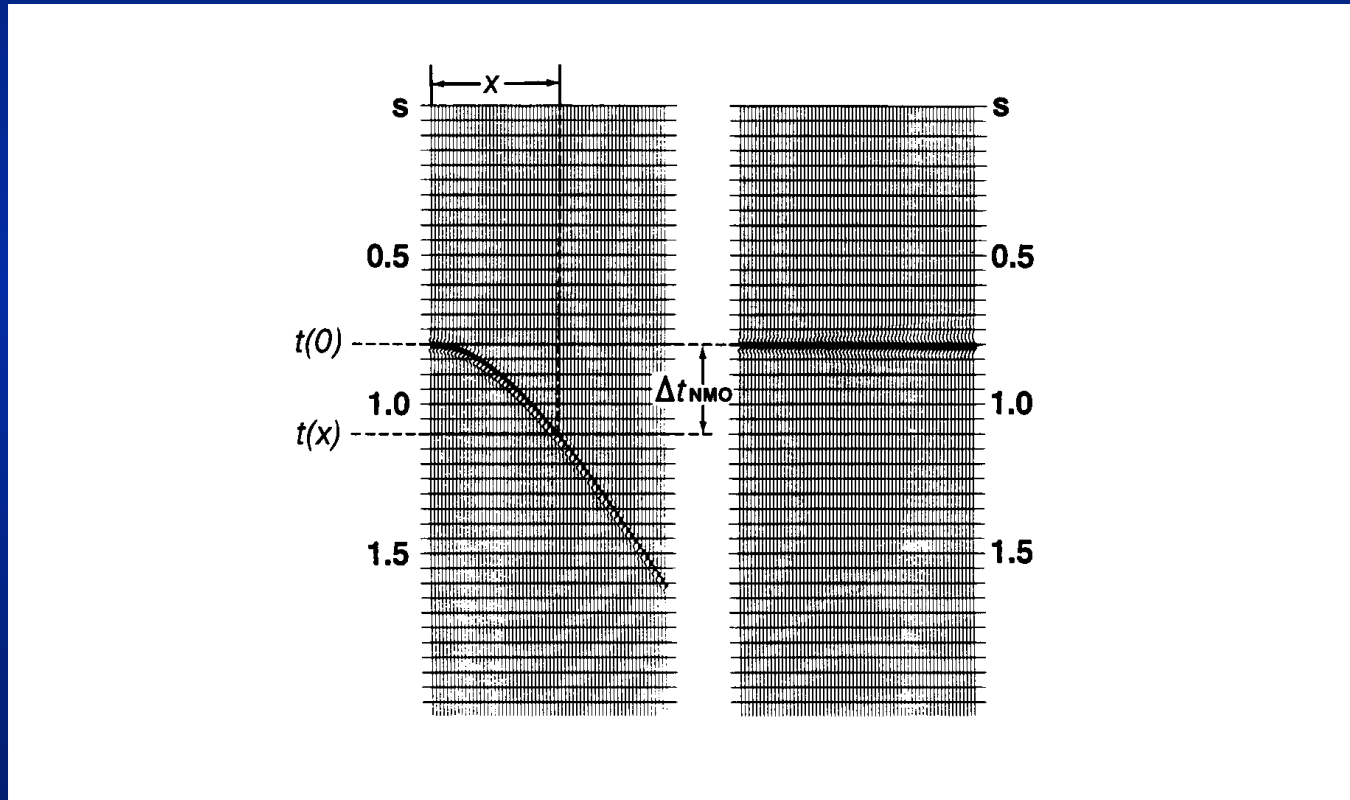
Stacking Velocity

The velocity associated with the best-fit hyperbola to correct time drift on CMP gathers and align signal from the same reflector.



Stacking Velocity (V_{nmo})

The velocity associated with the best-fit hyperbola to correct moveout on CMP gathers and align signal from the same reflector



Stacking Velocities

- The velocities measured during Velocity Analysis
- Often (erroneously) referred to as RMS velocities (V_{rms})
- Increase in value in the presence of dipping events
- Stacking velocity (V_{nmo}) approaches RMS velocities (V_{rms}) only for small offsets

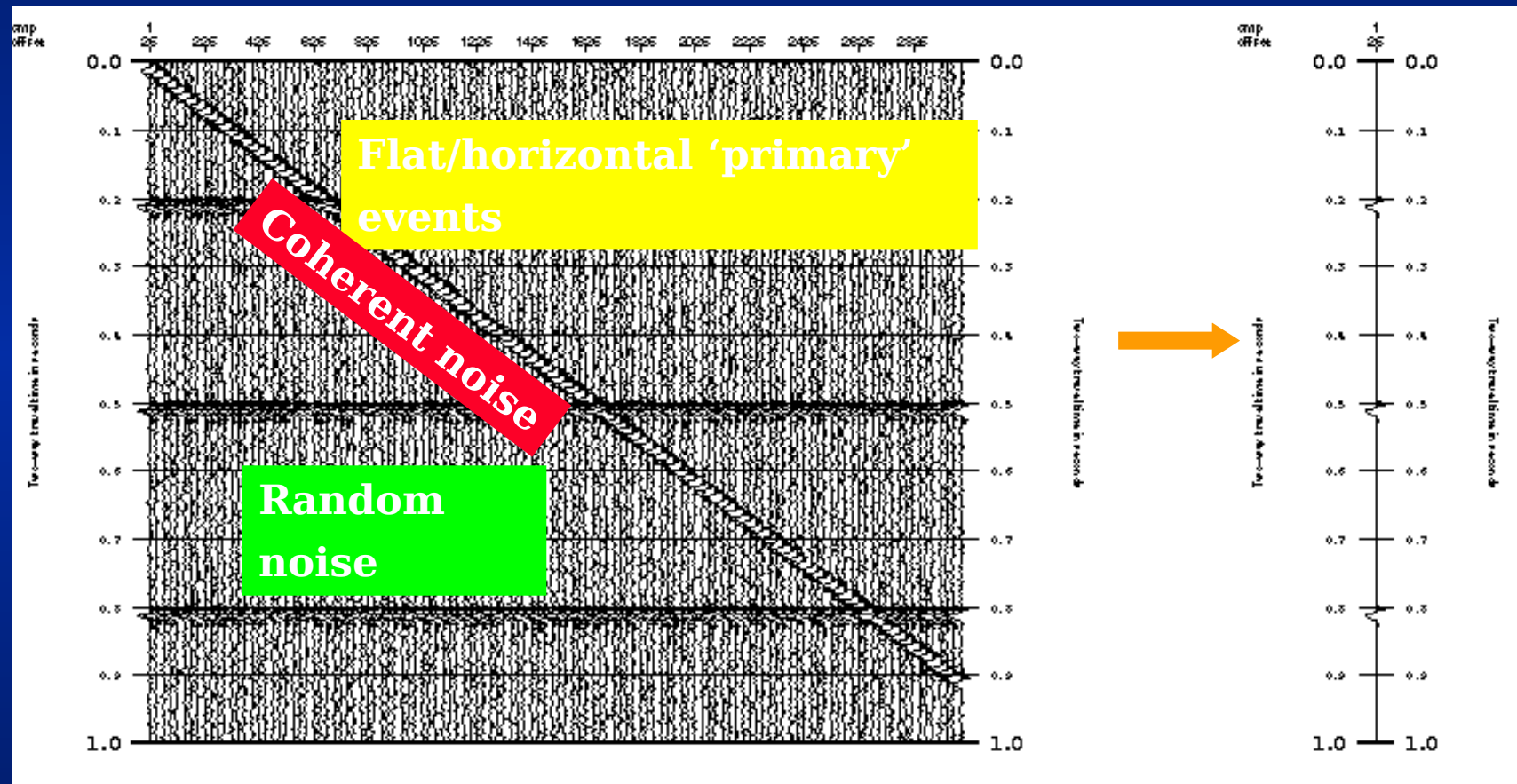
The Stacking Process

CMP gather



Basic stack

$$\frac{\text{Sum of trace amplitudes}}{\text{Number of traces}}$$



The Power of Stack

- Relies on signal being in phase and noise being out of phase

i.e. primary signal is 'flat' on the cmp gather after NMO corrections

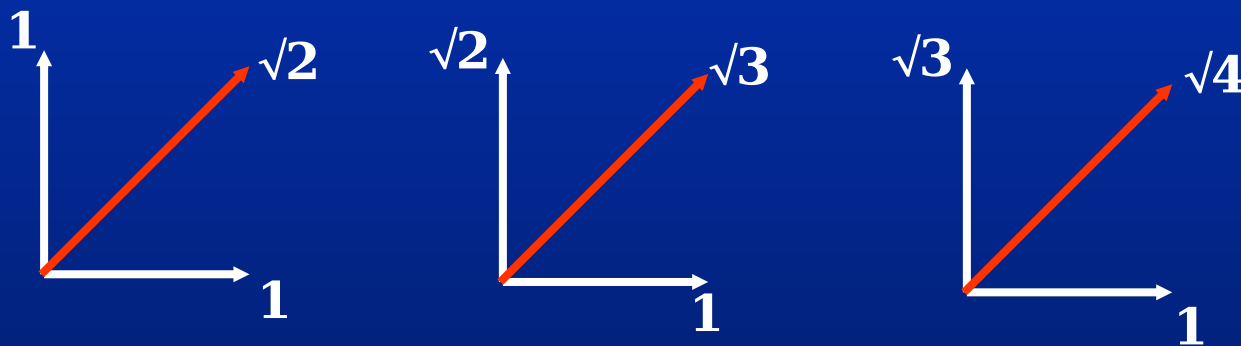
- A spatial or K- filtering process
- Data reduction - usually to [almost] 'zero-offset' trace
- Attenuates coherent noise in the input record (to varying degrees)
- Attenuates random noise relative to signal by up to $\sqrt{N}$
where N = number of traces stacked (i.e. fold of stack)

The Power of Stack

Assume N vectors representing the **noise component** on N traces

Each vector has a constant amplitude (1) but **random phase**

Phase difference between any two vectors in range 0 - 180 degrees with average being 90 degrees for several such vectors



Amplitude of noise is only increased upto a factor of $\sqrt{N}$
Whereas the signal (which is in phase) would increase by a factor of N

Amplitudes of a stacked trace

- If we have a cmp gather with 8 traces the last 3 of which have been muted, with the following amplitudes values at a particular time

5,3,0,-2,4,0,0,0

what would be the amplitude of the stacked trace at that particular time?

• 2

NMO and CMP Stack - recap

- NMO is applied to align our primary events on CMP gathers -

function of trace 'offset'

- STACK results in data reduction, increased Signal to Noise and zero-offset (almost) data -

operates best with good trace 'offset' distribution

Trace offset determined from: **GEOMETRY**

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